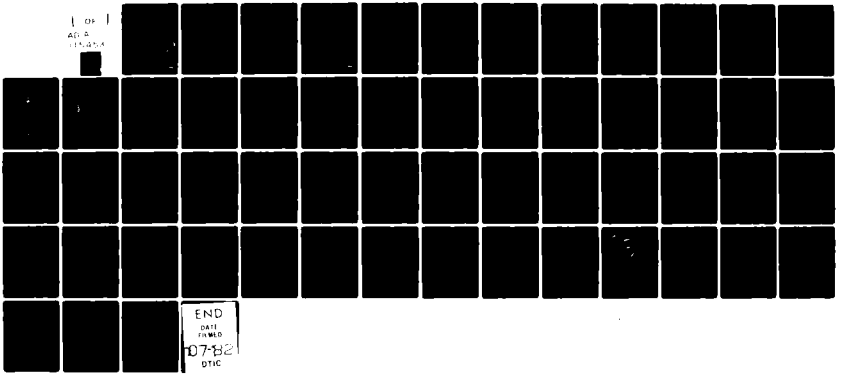
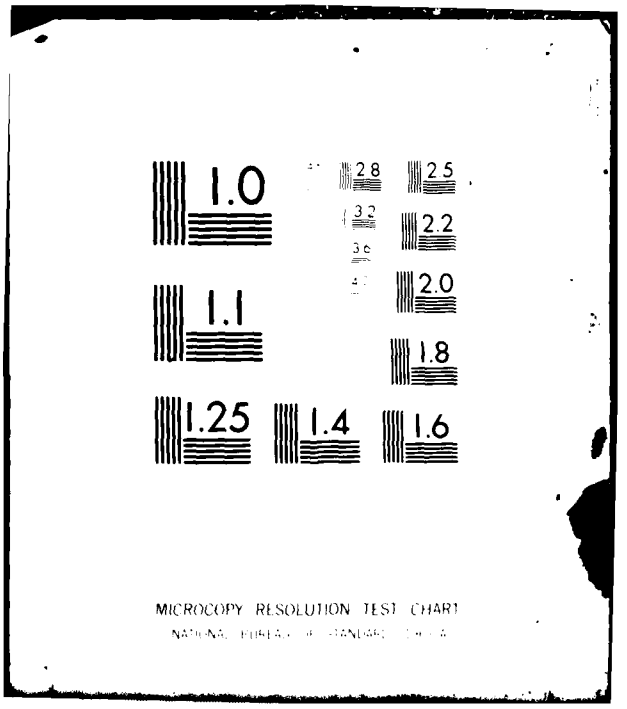
AD-A115 453 TRW DEFENSE AND SPACE SYSTEMS GROUP REDONDO BEACH CA F/G 9/2
A STUDY OF EMBEDDED COMPUTER SYSTEMS SUPPORT. VOLUME I. EXECUTI--ETC(U)
SEP 80 F33600-79-C-0540
UNCLASSIFIED TRW-34330-6003-UT-00-VOL- NL




1.0
2.8
2.5
3.2
2.2
3.6
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

34330-6003-UT-00

A STUDY OF
EMBEDDED COMPUTER SYSTEMS SUPPORT

VOLUME I
EXECUTIVE OVERVIEW

September 1980

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

CDRL 05
Contract Number F33600-79-C-0540

Prepared for
Air Force Logistics Command AFLC/LOEC
Wright Patterson AFB, Ohio 45433

UNCLASSIFIED/UNLIMITED

TRW
DEFENSE AND SPACE SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH • CALIFORNIA 90278

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A115453	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Embedded Computer System Support Volume 1-Executive Overview		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER 47169A
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) F33600-79-C-0540
9. PERFORMING ORGANIZATION NAME AND ADDRESS TRW Systems Inc One Space Park Redondo Beach, CA 90278		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS HQ AFLC/LOEE Wright-Patterson AFB, OH 45433		12. REPORT DATE Sept 1980
		13. NUMBER OF PAGES 55
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for Public Release, Distribution Unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Recommendations pertaining to administrative and programmatic initiatives are presented in this volume. Companion documents dated Oct 81 and Sep 80, same contract number.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Materiel Management	ECS	Computerized Systems
Logistics Support	Weapon Systems	Avionics
Logistics Management	Technolgy Forecasts	
Planning	Program Management	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This volume 1, executive overview, is one of several individually bound volumes that constitute the phase 11 final report "study of Embedded Computer Systems Support (ECS)". The purpose of this study was to develop a long range plan for use by HQ Air Force Logistics Command (AFLC) to manage and maintain Embedded Computer Systems on a command-wide bases in the 1980's. (See related volumes: LD 47169B, C, D, E, F, G, H, J, K and L).

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

ITEM 20 (con't)

Conclusions: Numerous conclusions pertaining to ECS support and management by HQ, AFLC on a command-wide basis are presented throughout this report.

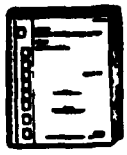
Recommendations: Numerous recommendations pertaining to general and specific changes for improvement in ECS support by HQ, AFLC are presented throughout this document.

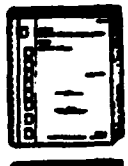
34330-6003-UT-00

A STUDY OF
EMBEDDED COMPUTER SYSTEMS SUPPORT

VOLUME I

EXECUTIVE OVERVIEW





September 1980

CDRL 05
Contract Number F33600-79-C-0540

Prepared for
Air Force Logistics Command AFLC/LOEC
Wright Patterson AFB, Ohio 45433

ONE SPACE PARK • REDONDO BEACH • CALIFORNIA 90278

TRW
DEFENSE AND SPACE SYSTEMS GROUP

FOREWORD

This volume is one of nine individually bound volumes that constitute the Phase II Final Report "Study of Embedded Computer Systems Support" for Contract F33600-79-C-0540. The efforts and analyses reported in these volumes were sponsored by AFLC/LOEC and cover a reporting period from September 1979 through September 1980.

The nine volumes are

Volume	Title
I	Executive Overview (CDRL 05)
II	Selected ECS Support Issues: Recommendations/ Alternatives (CDRL 02A)
III	Requirements Baseline: Aircrew Training Devices (CDRL 02A)
IV	Requirements Baseline: Automatic Test Equipment (CDRL 02A)
V	Requirements Baseline: Communications-Electronics (CDRL 02A)
VI	Requirements Baseline: Electronic Warfare (CDRL 02A)
VII	Requirements Baseline: Operational Flight Programs (CDRL 02A)
VIII	ECS Technology Forecast (CDRL 03)
IX	National Software Works Investigation (CDRL 04)

CONTENTS

CONTENTS (Concluded)

TABLES

ILLUSTRATIONS

1. INTRODUCTION

Support of Embedded Computer Systems (ECS) in the 1980's presents a major challenge to the Air Force Logistics Command (AFLC). Major new systems in the active force inventory and those currently in development make extensive use of digital technology. In addition, existing weapon systems are being modified to incorporate digital technology. Several of these systems containing embedded computers have been deployed and problems associated with their support surfaced in the early 1970's. Many of these problems, particularly the support of computer programs, can be attributed to past acquisition practices as well as a major shift in support philosophy that also occurred in the early 1970's. This shift towards increased government support was designed to increase government control to provide improved mission responsiveness.

The Logistics Command responded to this transition to the digital operational and support environment with new and innovative support approaches and new facilities and trained personnel to ensure that adequate support was provided for fielded combat units. Concurrent with the Air Force and the Department of Defense development of policy and guidelines for ECS support, AFLC initiated activities on a case-by-case basis to establish software support facilities at the various Air Logistics Centers.

While these early efforts were primarily focused on support facilities for aircraft related operational flight programs, AFLC was also involved in a broad range of activities for support of other embedded computer systems. One of these early efforts was Air Force Project Pacer Flash. The Pacer Flash group looked at three categories of software support: (1) Operational Flight Programs (OFP), (2) Automatic Test Equipment (ATE), and (3) Aircrew Training Devices (ATD). Two other categories were added later: Electronic Warfare (EW) and

Communications-Electronics (C-E). Other efforts included involvement in the development of AFR 800-14 Volume I and II and DODD 5000.29. In addition, AFLC took an early lead in the development of Computer Resource Integrated Support Plans (CRISP) and Operational Support Configuration Management Procedures (O/S CMP). Based on this early involvement and experience and a continuing requirement to improve and refine support systems effectiveness and reduce support costs for an ever increasing number of systems, AFLC is seeking additional new support initiatives.

Accordingly, several complementary efforts are in progress in response to this requirement for management and technical focus on the support of embedded computer systems. For example, (1) a recently published AFLC Regulation (AFLCR 800-21) implements the policies of AFR 800-14 and other related directives in the support of defense systems, (2) effort is underway to project and define support requirements through development of a "Statement of Need," (3) a joint AFLC-AFSC effort has been initiated to investigate and demonstrate the utility of the National Software Works to maintain software systems within AFLC, and (4) an AFLC Computer Resource Review Group (CRRG) was recently established to coordinate command policy and delineate responsibilities. In addition to these in-house activities, AFLC initiated this contractor study of Embedded Computer Systems Support.

1.1 ECS SUPPORT STUDY DEFINITIONS

Computer resources consist of the totality of computer equipment, computer programs, computer data, associated computer documentation, contractual services, personnel, and computer supplies.

The pervasiveness of digital applications in individual weapon systems and in the aggregate makes it difficult to separate precisely or place the various weapon systems in categories or to define the various categories of embedded computer systems. Figure 1-1 summarizes the definitions of categories of ECS support assumed for purposes of this study.

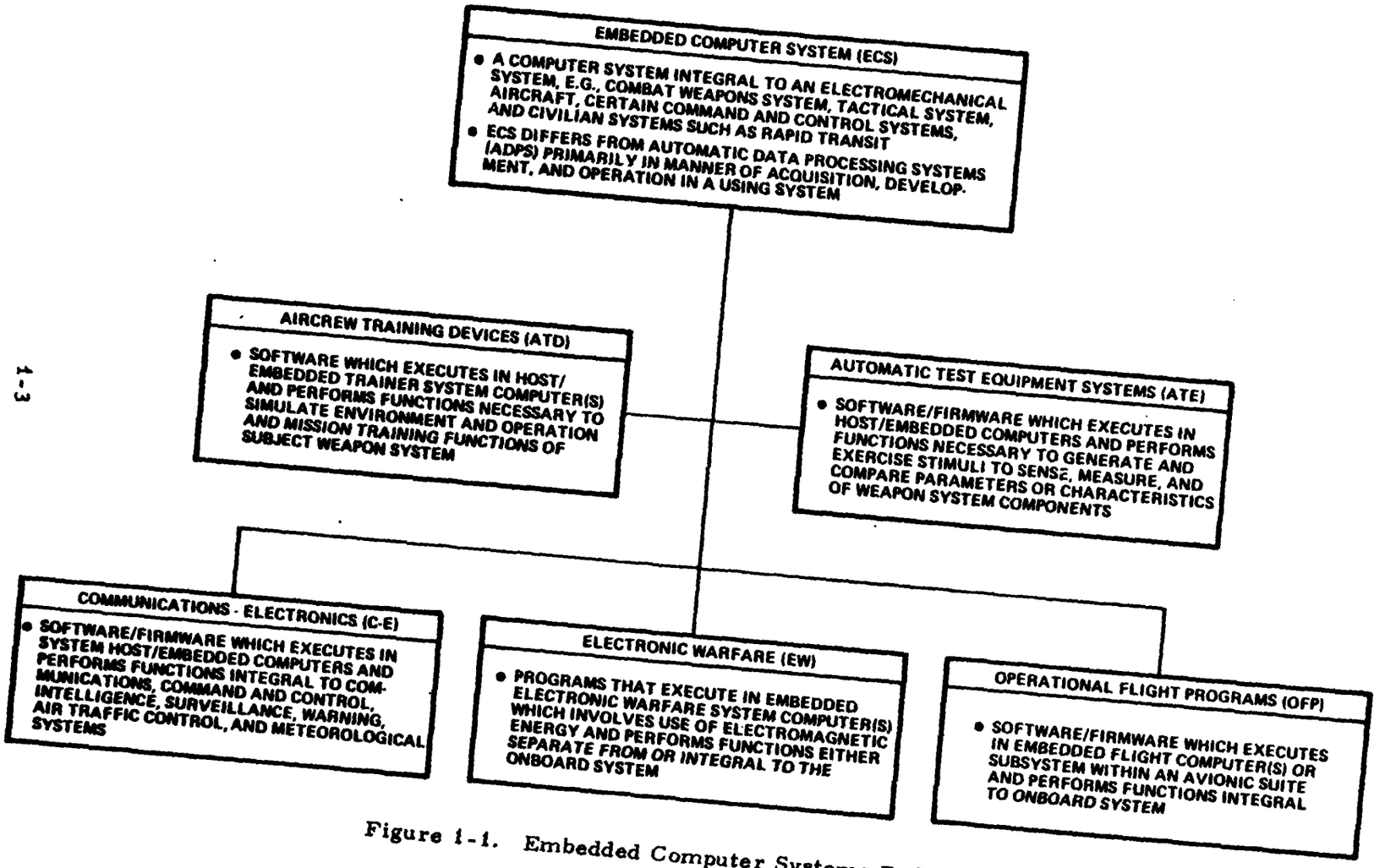


Figure 1-1. Embedded Computer Systems Definitions

The key attributes of an embedded computer system are

- It is a computer system that is physically incorporated into a larger system whose primary function is not data processing.
- It is integral to such a larger system from a design, procurement, or operations viewpoint.
- Its outputs generally include display data, computer control signals, and computer data.

1.2 OBJECTIVES AND SCOPE OF THE STUDY

The purpose of this study is to develop a long range plan for use by HQ AFLC to manage and maintain Embedded Computer Systems on a command-wide basis in the 1980's. The study effort was initiated on 28 September 1979 and is divided into three phases as shown in Figure 1-2, with the following specific tasks to be accomplished over a period of 17 months.

- Develop a program plan which describes the study approach, procedures and schedules (Phase I: Approved 19 November 1979).
- Establish a baseline for current ECS support functions and requirements (Phase I and II).
- Assess and forecast major technology impacts on future systems and their attendant support requirements (Phase II).
- Investigate the potential use of networking and the National Software Works (NSW) and other support concepts (Phase II).
- Develop a long range plan with accompanying methodology and implementation procedure for improving the AFLC Embedded Computer System Support posture for the 1980's (Phase III).

1.3 PHASE II FINAL REPORT

During the past year, several closely related reports were written. This Phase II final report, which consititutes the contract deliverables, contains the work completed through September 1980. This report consists of nine volumes as shown in Figure 1-3.

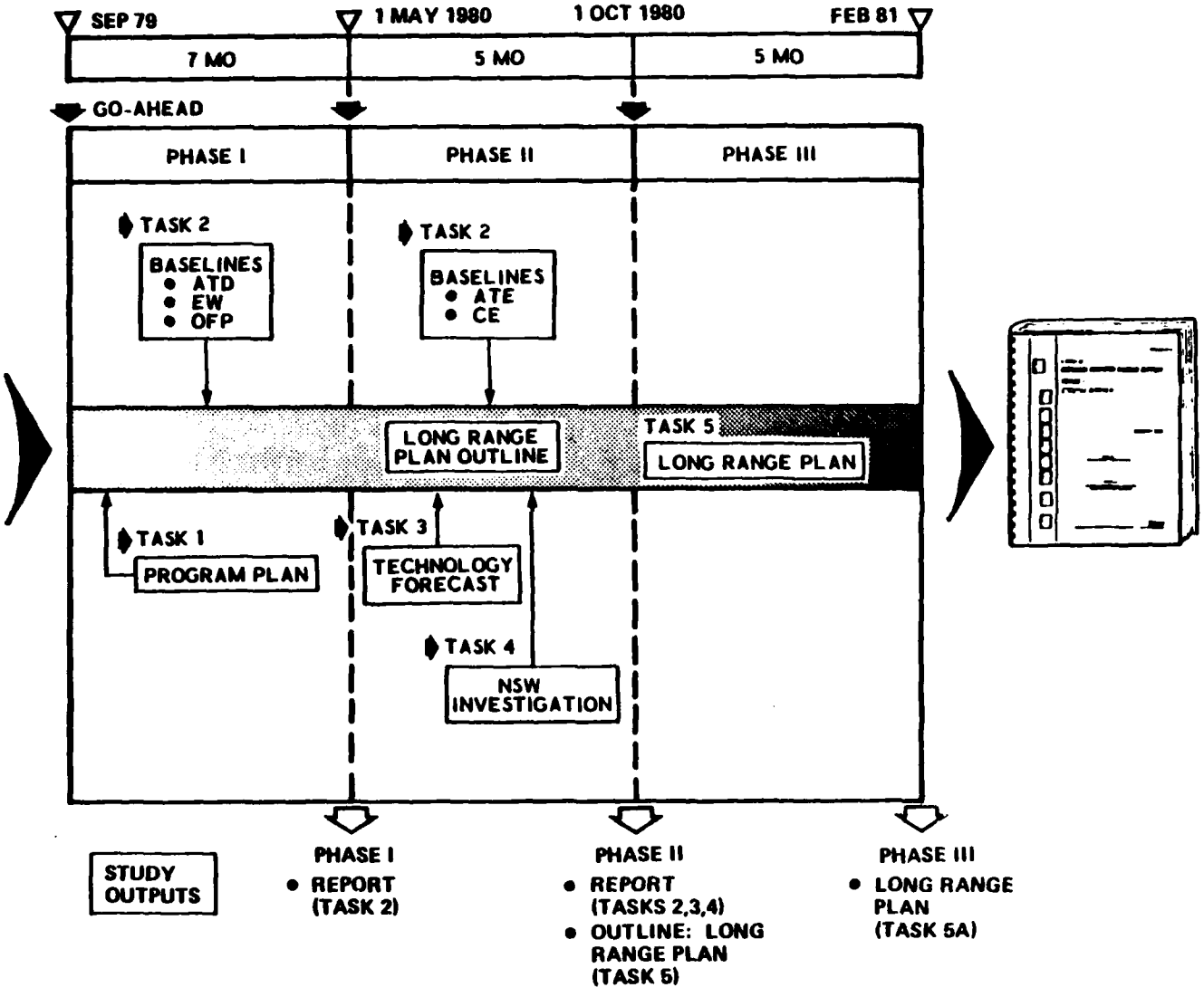


Figure 1-2. Study Activity and Flow

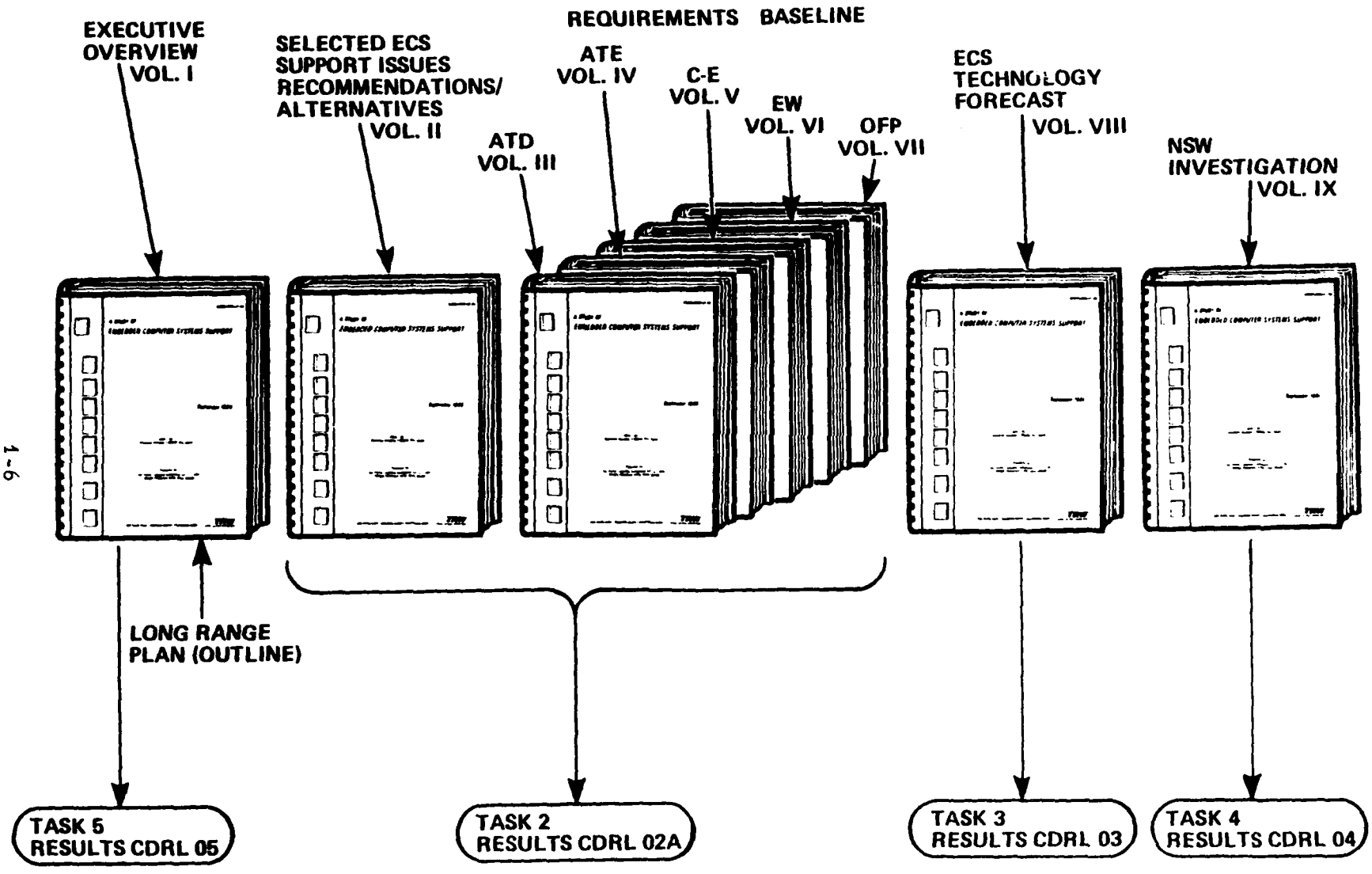


Figure 1-3. Phase II Final Report

1.3.1 Volume I: Executive Overview

This volume provides background information, describes the contents of the report and discusses the study methodology employed during the study. It also summarizes the major study findings. An outline of the long range plan which is to be developed during Phase III of the study is also included with this volume as Section 3.

1.3.2 Volume II: Selected ECS Support Issues, Recommendations/ Alternatives

This volume contains a discussion and analysis of selected ECS support issues related to the current ECS support posture. It summarizes these issues and separates them into administrative/programmatic recommendations/alternatives.

1.3.3 Volumes III-VII: Requirements Baseline

These five volumes contain the requirements baselines and current support posture assessments for the individual ECS categories. Each of the volumes is structured generally as follows:

- ECS Category Description

  A description of the particular ECS category and the mission functions that it performs.

- ECS Support Requirements

  A discussion of the common ECS support requirements as they relate to the particular category and identification of ECS support requirements unique or peculiar to the category.

- ECS Support Concept

  A description of the support concept designated for the particular ECS category and a discussion of the facility elements and concept as implemented at the various Air Logistics Centers.

- Representative ECS Systems

  This section examines in detail selected ECS support systems within the particular category to enable an assessment of the effectiveness of the subject support system as well as the current posture for the ECS category.

- Assessment of Current ECS Support Posture

  This section summarizes the current support posture for the category.

1.3.4 Volume VIII: ECS Technology Forecast

This volume contains an identification of key trends related to computer resources and an analysis of major technologies and forecasts their anticipated impact on the support of ECS by 1990.

1.3.5 Volume IX: National Software Works Investigation

This volume contains an assessment of the potential applicability of the National Software Works to the ECS support mission. It focuses on the capabilities currently available and their applicability for the use in the near-term support of ECS common and unique support requirements. Networking as it applies to ECS support needs is also addressed.

1.4 ECS STUDY METHODOLOGY

The study methodology employed during the past 12 months for Task 2 (requirements baselines) was designed to systematically generate data to support a sequential and iterative analysis of support requirements, activities, support concepts, and alternatives for each of the five ECS categories. Data collection and analysis, which was a major activity for each ECS category, included a review of existing and planned weapon and support system documentation provided by AFLC and by visits to HQ AFLC and each of the Air Logistics Centers for briefings and interviews with management and engineering personnel. The effort was conducted to acquire or verify sufficient weapon and support system data to facilitate analysis and documentation of ECS support requirements and concepts for a more in-depth analysis of a limited number of representative weapon and support systems within each ECS category.

Support requirements were also examined to determine requirements common to all five ECS categories and those which are unique or peculiar to a particular ECS category. Each ECS category report discusses the common ECS support requirements, which are described as a generic process, and the unique requirements for that category. These requirements formed the baseline requirements as well as the basis for determining if, or to what degree, the support concept as currently identified

and implemented was effective in providing support for the category. Assessments were made based upon analysis of a limited number of weapon and support systems chosen from each ECS category. Consequently, these assessments and the overall posture assessments for each category are "snapshots" of the current support posture, rather than an in-depth examination of every facet of ECS support.

The study methodology for the other Phase I and II tasks, i.e., Task 3 (technology forecast), Task 4 (NSW investigation) and Task 5 (long range plan annotated outline) was tailored to the specific task. The technology forecast, for example, was accomplished by forming a Technology Working Group of senior engineers and scientists with expertise in the technology areas pertinent to the AFLC ECS support role. The NSW applicability assessment, on the other hand, was accomplished primarily by a senior principal investigator, with close coordination and review by personnel experienced in networking and actual performance in a variety of NSW related contractual tasks for Rome Air Development Center. A working groupwas also formed to further examine ECS support problems and issues that surfaced during the baseline investigations. This group called the Operations and Support Working Group, consisted primarily of TRW field site managers and other engineers and scientists collocated with AFLC engineering divisions at various Air Logistics Centers. This group wrote a series of "white papers" on selected topics which were identified and coordinated as major problems and issues in the support of ECS. In the preparation of the long range plan outline, another approach was used. This activity was infused with close coordination with TRW management personnel, members of the ECS study team, and extensive interaction with HQ AFLC management and technical personnel. The overall study approach used in Phase II is shown in Figure 1-4.

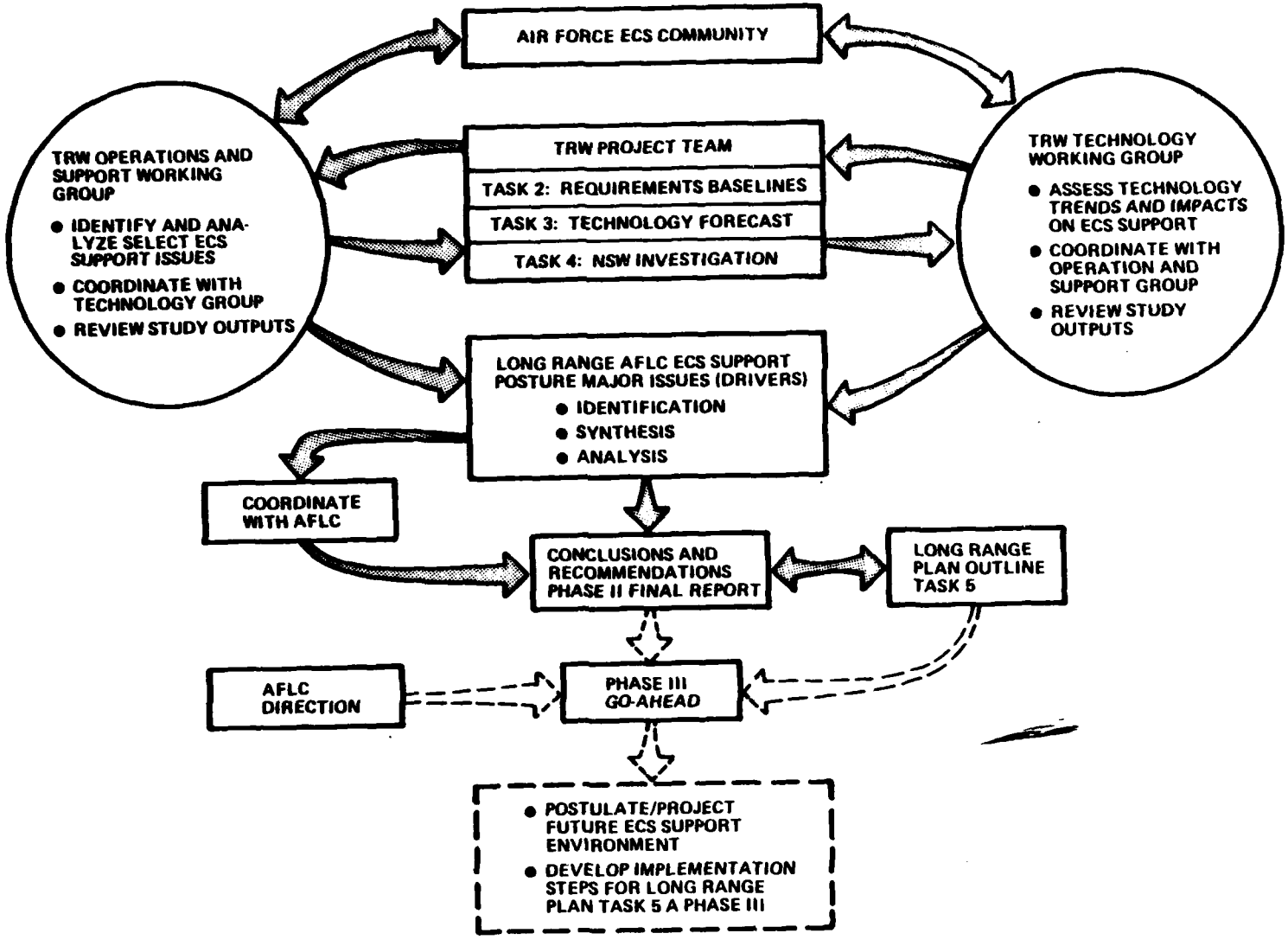


Figure 1-4. Phase II Study Approach

2. PHASE II SUMMARY OF ECS STUDY MAJOR FINDINGS

This section contains a summary of the conclusions and recommendations detailed in the separate volumes of the Phase II final report. Many of the problem areas affect all of the ECS categories or are otherwise interrelated; therefore, only the major study findings are included in this overview. This section is presented in four parts: selected ECS support issues, requirements baselines, ECS technology forecast, and National Software Works investigation. These subsections correlate with the individual volumes of the Phase II report as shown in Table 2-1. Each subsection contains a brief introductory discussion followed by major recommendations and alternatives as applicable.

2.1 SELECTED ECS SUPPORT ISSUES

The requirement to provide support for embedded computer resources is significantly different from the traditional role of buying, supplying, transporting, and maintaining systems. The reprogramming of embedded computer software has placed AFLC in an engineering intensive, mission-oriented position. This role change is symptomatic of technological advances, bringing both technical and management difficulties. To complement the significant strides made by AFLC in preparing for the impact of digital technology, this study was commissioned to examine critically the AFLC current ECS support posture to determine if the support posture could be more efficiently aligned to current and future support requirements. The following are the most important management issues as determined by this study.

- ECS readiness support concept
- Personnel and training
- Microprocessors and firmware
- AFR-800 versus AFR-300 acquisition and support
- Configuration management
- Facility planning, funding, and maintenance
- Funding
- Product and data quality at transition
- Management structure

Table 2-1. Major Study Topics and Supporting Data References

Major Study Topics	Supporting Data
Selected ECS Support Issues (Section 2.1)	
• ECS readiness support concept • Personnel and training • Microprocessors and firmware • AFR-800 *vs.* AFR-300 acquisition/support • Configuration management • Facility planning/funding/maintenance • Funding • Product/data quality at transition • Management structure	Volume II: Discussion and analysis of selected embedded computer system support issues related to the current ECS support posture. Summarizes these issues and separates them into suggested administrative and programmatic actions.
Requirements Baselines (Section 2.2)	
• ECS software and associated documentation • ECS support tools • ECS support policy/guidance	Volumes III-VII: Documents requirements baselines for five individual ECS categories: • Aircrew training devices (Vol. III) • Automatic test equipment (Vol. IV) • Communications-electronics (Vol. V) • Electronic warfare (Vol. VI) • Operational flight programs (Vol. VII)
ECS Technology Forecast (Section 2.3)	

• Key trends affecting ECS support
• Technologies affecting ECS support
  • Intercenter networks
  • Distributed integration support facilities
  • Computer nets
  • LSI, VHSIC
  • High order language
  • Emulation
  • Standardization
  • Built-in test
  • Operator-computer interaction
	Volume VIII: Identification, assessment and forecast of the probable impact of computer resource related technology on the support of embedded computer systems. Includes survey and review of ongoing industry efforts and existing studies such as the Computer Technology Forecast and Weapon System Impact Study (COMTEC-2000).

National Software Works Investigation (Section 2.4)	
• NSW as a near-term capability • NSW as a future capability • Applicability of networking to ECS support	Volume IX: Discusses and compares NSW status and tools with current and projected ECS support requirements. Assesses general applicability of computer system networking as it would apply to ECS support needs.

2.1.1 ECS Readiness Support Concept[†]

Many electronic warfare and weapon systems currently, or in the near future, under the support responsibility of AFLC are impacted by changes in adversary threats. As the threats change, the capabilities of friendly systems need to be updated accordingly. The frequency and significance of threat changes are such that rapid reaction to the threats is tantamount to the success of friendly systems. An adequate support posture does not exist to meet the responsiveness and engineering sophistication required. Specifically, deficiencies fall into the categories of (1) the lack of sufficient intelligence support to the ALC organization responsible for software engineering to determine specific threats, and (2) the lack of a concept of operations and designated resources (for other than EW systems) to make software changes in response to adversary actions and capabilities. Today's AFLC ECS manager must have access to intelligence data that reflects adversary intentions and hard technical data on the threat environment. These data are required to provide timely engineering support in fire control radars, communications systems, EW systems, etc. In addition, resources (equipment, facilities, and personnel) must be available to provide software changes to counter observed threats in either a pre-emptive or quick reaction capability (QRC) mode.

RECOMMENDATIONS

- Initiate actions that will provide a stimulus and effectiveness monitoring capability for key avionics systems.[‡] These actions should include:
  - Investigation of incorporating basic stimulus and monitoring equipment as an integral part of each AISF.

[†] Detailed discussion in Section 2, Volume II.

[‡] Key systems should include, but not be limited to, terrain avoidance/terrain following radars, fire control/nav aid radars, IFF and selected communications system. Particular emphasis should be given to the F-15, F-16, E-3A, F-111, and JTIDS systems.

- Should this approach be taken, then an overall AFLC management oversight program should be implemented to ensure that the stimulus and the monitoring/data reduction within each AISF is standardized, that the results are transferrable, and that the intelligence data/stimulus waveforms are "valid" and universally used throughout the ALC's.

- Investigation of the feasibility of using an Electronic Warfare Open Loop Simulation (EWOLS) similar to that being developed at WR-ALC/MMR. Using this approach, the current EWOLS concept would be expanded to include the capability to generate various jamming waveforms.

- At the same time, emphasis should be placed on documenting and developing, as an integral part of the stimulus/monitoring equipment, a pre-emptive engineering and QRC support capability. Under this concept, the stimulus/monitoring equipment not only serves to stimulate and evaluate the baseline data/avionics system, but also allows the evaluation of changes to both the stimulus and the avionics system in a pre-emptive engineering and QRC development and test role.

- Rank fire control radars and associated "core of trained personnel" as first priority among avionics systems.

  The following ranking rationale applies.

  - These systems are currently deployed in the field and with the development of the "beyond visual range" air-to-air missiles, it is essential that these systems be capable of undegraded performance in an ECM environment.

  - The numerical superiority of the Soviets in a Central European environment requires the F-15/F-16 systems be able to engage effectively with extended "beyond visual range missiles" and to do so with a high confidence kill probability on a single shot basis.

  - Soviet REC is targeted against U.S. fire control radars. One of the specific objectives of this targeting approach is to deny U.S. aircraft the advantage of long-range directed air-to-air missile engagements.

- Train and maintain within each support facility a core of expertise.

- Conduct an extensive review of the current and future ALC's mission and document requirements for use and storage of classified data including both "Friendly/ Blue" and Foreign Intelligence Data.

  The following should be included in this review.

  - Identification of the type and classification of the various ALC ECS support facilities as a function of both the classified intelligence material handling/ storage and the classified nature of the "Friendly/ Blue" systems. This effort should include not only a review of the overall facility classification, but also identification of required work areas and conference facilities.

  - Analysis and identification of the type, number, and level of classification of the personnel required to support each ALC.

  - Documentation and implementation of appropriate HQ AFLC direction in the area of specific responsibilities for obtaining and providing the required intelligence support at the various ALC's. Specific consideration should be given to publication of an AFLC implementation regulation for AFR 200-1.

  - Based upon the above work, development of a command-wide, long-range plan for obtaining, storing, and working with foreign intelligence data.

- In coordination with operational commands and the intelligence community, develop a concept of operations for reprogramming critical mission embedded computer systems. The EWIR concept used for EW reprogramming may be used as a guide.

2.1.2 Personnel and Training[†]

With USAF tactical and strategic effectiveness weighing more and more heavily upon the ability to provide highly interactive, rapidly responding, economical embedded computer system support, the

[†] Detailed discussion in Section 3, Volume II.

dependence upon AFLC human resources with engineering and computer science skills will heighten markedly in the 1980's. Approximately 3,500 organic personnel (collectively costing on the order of $100 million per annum) are projected for the five Air Logistic Centers in FY 86. This projection is twice today's authorized manning level. Acquiring, training, and retaining such an organic work force, particularly with the skill mix required, presents a mammoth challenge. Many of the undesirable characteristics inherent in the current personnel and training area deepen this challenge. Among the chief issues are: (1) inadequacies in the manpower requirements, definition and planning process, and in the manpower justification and authorization process as well as in the recruiting activities; (2) short-comings in personnel training, source selection, training plans, funds, and scheduling; and (3) problems related to promotional policies, responsibility and authority balance, professionalism, and technical challenges.

RECOMMENDATIONS

- Develop, within guidance provided by Headquarters AFLC (e.g., via AFLCR 800-21, AFLCR 400-XX)
  - Detailing of the various support concepts and alternatives (and accompanying decision rationale) requisite in arriving at an optimum approach (i.e., a more detailed version of the logic paths sketched for the AFLC Generic Logistic Decision Tree in AFLCR 400-XX). A definative breakout of governmental and readiness functions should be included. Organic staffing logic based upon an average employee tenure of 4 to 7 years, rather than the usual 15 to 20 years, is recommended.
  - Specific guidance and policy regarding the consolidation of resources (including cross-training) across ALC's and ECS's.
  - A generic breakout of functions and activities required in the software operations and support job for a given ECS as well as for a multi-ECS environment.
  - A skill level index with associated position descriptions and manpower quantity algorithms.

- A step-by-step, time-phased trace depicting the manpower acquisition (authorization) process, including new starts and other additive elements, as well as a responsibility breakdown between Headquarters AFLC offices, ALC offices, and Manpower Evaluation Teams.

- An expansion of the CRISP content to include contingency planning for embedded computer resources in the event manpower, funding, and Military Construction Programs inherent in the primary support role are delayed or denied.

- Take steps to have software manpower removed from the "additive" category and placed in the manpower baseline with other operations and maintenance functions.

- Continue attempts to establish special categories and high grade authorizations for ECS engineers.

- Develop a top level training plan, in coordination with ATC and AFIT for ECS operations and support engineers and managers. The development of a formal training program (such as is currently conducted for flight training, maintenance officer's school and logistics management school) for software engineers and for software managers is strongly urged.

- Establish in Headquarters AFLC a senior position for an expert in ECS operations and support who has first-hand experience in the problems encountered by the ALC's. This position, which might be rotational in nature, should be filled from the ALC's. The chief role of this position would be to interact with the ALC's and to provide inputs to and participate in the command-wide ECS support planning and decision process.

2.1.3 Microprocessors and Firmware[†]

The unique problems brought about by the massive influx of microprocessors and firmware into current avionics systems impact both technical and management considerations. From an AFLC standpoint, establishing a comprehensive support posture requires an understanding

[†] Detailed discussion in Section 4, Volume II.

and resolution of these unique aspects. Major problems impacting support of microprocessors and firmware are: (1) lack of common definitions, procedures, configuration management practices, and policies for use within AFLC and AFSC; (2) lack of standard, well-equipped microprocessor support facilities; (3) additional requirements placed on logistic planning; and (4) lack of common agreement with AFSC concerning data requirements.

RECOMMENDATIONS

- Formulate a joint AFSC/AFLC regulation concerning microprocessor and firmware definitions, concept of operations, configuration management practices, policies, and procedures. This effort should include policies on HOL's and data requirements and the need for firmware DID's.
- Develop and install a standard, well-equipped, growth-oriented microprocessor laboratory at AGMC and each of the five ALC's.

2.1.4 AFR-800 versus AFR-300 Acquisition and Support[†]

Currently, ECS support organizations are unsure about the interpretation of existing directives pertaining to the procurement of computers used in the support of avionics systems. This uncertainty stems from implementing regulations describing two approval processes to satisfy the intent of Public Law 89-306 (Brooks Bill). AFR-800 and AFR-300 series regulations define different approval and procurement paths for weapon system and/or support system computers and other system components. Most ECS support managers agree that embedded computer resources, including ECS support facility computers, should be exempt from the AFR-300 series acquisition policy but they concede that DOD guidance is not sufficiently clear. The Joint Logistics Commanders have prepared and submitted candidate changes to improve the clarity of DODD 5000.29 in order to define clearly embedded computer resources and include commercial computers if they are integral to an operational or supporting system. These changes should be adopted.

[†] Detailed discussion in Section 5, Volume II.

2.1.5 Configuration Management[†]

To fully capitalize upon the weapon system flexibility facilitated through embedded computer system software, an effective, efficient configuration identification, control, and status accounting system is mandatory. Although configuration management for hardware has been implemented quite successfully, software (less visible, more pervasive) has not been as manageable. The chief difficulities in ECS software configuration management are: poorly established configuration item baselines, less than adequately defined change control methods, and inadequate motivation and resources to implement effective procedures. Establishing more detailed procedures and tools which are standard across ECS's, placing emphasis on pre-deployment IV&V, and invoking more crisply defined roles and missions in C-E and ATD will lead to more effective ECS software CM in the 1980's.

RECOMMENDATIONS

- Detail the configuration management guidance provided in AFR 800-14 and AFLCR 800-21 into ALC division and branch level procedures, advisedly in the form of operating instructions (OI's). Action should be taken by Headquarters AFLC to ensure that such procedures are consistent across all ECS's (i.e., OFP, EW, ATD, C-E). These OI's should be employed as items for AFLC functional inspections.

- To enhance accuracy, speed, and cost effectiveness, develop a common set of CM tools (e.g., data management systems, requirements tracing tools, library systems) across ALC's and, where applicable, across ECS types.

- Conduct a tradeoff analysis to evaluate centralized change management as opposed to a decentralized process (for C-E and ATD). Roles and missions of involved agencies should be carefully considered. If split software support is determined necessary for a special situation, then support should be aggregated at one location with CM performed as a consolidated and coordinated effort.

[†] Detailed discussion in Section 6, Volume II.

2.1.6 Facility Planning, Funding, and Maintenance†

The timely establishment of ECS software support facilities is integral to a post-deployment software operations and support capability. The maintenance of such facilities over the life cycle of the system is of equal importance. The planning process for the ECS support facility involves explicitly defining all requirements, defining a support concept, estimating the cost of items to be acquired and/or developed, and obtaining the necessary approvals for the funding. This process is entwined in the federal budget and the Military Construction Program cycle and can span years. Changing personnel, poorly defined system and support requirements, cost changes, maintenance concepts, etc. that accompany this drawnout process only compound the delays. In addition, there are concerns that AFSC does not always provide adequate attention to life cycle support and that software development facilities may be unavailable or inappropriate for post-deployment use. Action at all levels of USAF management will be necessary to ensure an effective, efficient software operations and support posture in the 1980's.

RECOMMENDATIONS

- Develop a coordinated set of AFLC/AFSC guidelines for establishing and maintaining post-deployment software support facilities. These guidelines should address the gamut of planning, development, integration, demonstration, and maintenance activities as well as documentation requirements necessary to ensure that a timely, effective and efficient operations and support capability results. The *Software Acquisition Engineering Guidebook for Software Development and Support Facilities* recently developed by TRW under contract to AFSC, for Aeronautical System Division and Space Division, provides a solid basis for such guidelines.

- Develop checklists related to the Program Management Directive, Program Management Plan and the Integrated Logistics Support Plan which can be used by Headquarters USAF, AFLC, AFALD and field agencies participating in ECS acquisition to ensure that these documents properly address support facilities. USAF/LE should be encouraged to non-concur on all PMD's which do not adequately address post-PMRT support facilities.

† Detailed discussion in Section 7, Volume II.

- Incorporate facility planning and funding as part of the DSARC/AFSARC process, including these as specific items in the DOD Embedded Computer Resources and DSARC Process Guidebook.

- Establish software support facilities as early as possible in the acquisition cycle to maximize the benefits of the total spectrum of AFLC pre-deployment activities.

2.1.7 Funding[†]

The change from traditional AFLC activities to a more engineering intensive, mission-oriented role has been accompanied by a lack of appropriate funding initiative. A most notable example is the need for sophisticated support systems that require long lead times, are costly, and for which the need is not always understood. Management considerations can lead to budgeting and approving funds which are consistently short of real costs. As a result, these budgeting deficits are countered with sacrificed product quality, documentation waivers, austere training, and limited travel. The overall effect of shortfalls in funding is a net increase in the resources required to provide ECS support from a life-cycle perspective.

RECOMMENDATIONS

- Establish definitive funding lines within AFR 800-14 and the PMD's to route pre-PMRT funds to AFLC agencies to enable adequate participation in the acquisition process, acquire appropriate operations and support software support facilities, perform and participate in IV&V activities, and, in summary, establish support capabilities.

2.1.8 Product and Data Quality at Transition[‡]

Despite affirmative steps taken to improve product quality at PMRT, inadequately tested software, accompanied by insufficient data and support tools, continue to be transitioned to AFLC. Particular difficulties in this

---

[†] Detailed discussion in Section 8, Volume II.

[‡] Detailed discussion in Section 9, Volume II.

regard have been: (1) non-standard and unsupportable languages; (2) inadequate data provided on the software and the system; (3) unavailability and inadequacy of support tools; (4) lack of standardization and commonality considerations; (5) limited growth potential in the target computers; (6) incompleteness of development, i.e., baseline; and (7) absence of a demonstration of supportability. Additional AFLC/AFSC guidance, more direct involvement of AFLC in Full Scale Engineering Development, the adoption of more definitive ECS Documentation requirements, and the development of a guidebook for ECS source selection are avenues to the alleviation of these problems for ECS's transitioning in the 1980's.

RECOMMENDATIONS

- Develop an embedded computer resources guidebook for use by AFLC personnel participating in source selection activities. This guidebook should delineate ECS life-cycle support considerations and documentation and data issues as well as the ECS development methodology issues.

- Adopt a formal means of directly and actively involving the designated supporting ALC in the ECS acquisition cycle sufficiently in advance of PMRT to ensure that a high quality of well-baselined software and related documentation exists at transfer and that sufficient resources (personnel, training, equipment, facilities, support software, etc.) are available to AFLC to carry out timely life-cycle operations and software support. It is urged that, as part of this approach, the designated supporting ALC perform predeployment IV&V on development software and demonstrate a software support capability as a pre-requisite for transfer. These provisions should be made part of the AFR 800-4 PMRT plan.

- Establish joint AFSC/AFLC regulatory guidance that requires AFLC approval prior to any reprogramming of funds allocated for AFLC requirements to other acquisition areas.

2.1.9 Management Structure†

The management structure of AFLC is the result of an evolution spanning several years. With few minor exceptions, the structure has not been significantly altered to meet requirements for the support of ECS software. The structure was primarily developed to provide support to systems and items with primary emphasis on the hardware involved. The structure was further designed to achieve optimum spare and repair support without specific regard to engineering development. As the AFLC role has changed in recent years, particularly in regard to ECS software support, organizational adjustments may be warranted.

Recommendations for specific changes in ALC organization structure are not within the scope of this study, the advantages and disadvantages of several alternatives are discussed in Volume II. Further analysis of these, or other, organizational concepts would best be performed as an organic USAF effort.

† Detailed discussion in Section 10, Volume II.

2.2 REQUIREMENTS BASELINES

The requirements baseline discussions and recommendations relating to ECS software and associated documentation, support tools, and support policy and guidance resulted from investigation and analysis of the current AFLC ECS support baselines. Other ECS problem areas associated with each ECS category are discussed in Volumes III through VII. In this overview, a specific problem area is briefly outlined and its general affiliation with the ECS categories is described. Recommendations are provided for each problem addressed.

2.2.1 ECS Software and Associated Documentation

The documentation describing weapon system and ECS baselines is not adequate to facilitate efficient post-PMRT software development and support. Most documentation development has been an AFSC responsibility; however, in certain EW systems, the responsibility has rested with AFLC. Inadequate documentation (e.g., no source listing, no algorithm descriptions, mismatches between the software and its description, etc.) are common-place in all five ECS categories. This deficiency directly impacts ECS support and configuration control because the initial product baseline is not adequately defined.

Documentation format and the limits of coverage are inconsistent from system to system. Engineering data usually is the basis upon which technical order data, users and operators manuals, etc. are centered. Subsequent changes to the multiplicity of documents are processed very slowly and, in some ATD examples, the process takes 2 years or more. Change responsiveness is slow in all of the ECS categories to the extent that significant improvement is necessary.

Delivered software products have not generally been of sufficient quality to facilitate efficient software support within AFLC. This limitation has sometimes necessitated continued development of both the operational and support software. All ECS categories experience this effect to some extent with ATE and EW the most pronounced categories. Inadequate quality of software product baselines directly impacts AFLC's subsequent software development and support efforts.

Air Force regulations as well as good engineering practices dictate that an alternative geographical location be provided for copies of software masters. That is, a copy is preserved at a site other than the main control site so that inadvertent or intentional destruction of a master is not catastrophic to the software support capability. All ECS categories have a need for a software repository to preserve copies of software masters.

RECOMMENDATIONS

- Emphasize delivery of quality documentation and auditing documentation for adequacy and overall quality during acceptance testing prior to PMRT.
- Initiate action to design, develop, and acquire an automated documentation system which could be used for maintaining and updating engineering and technical order data.
- Intensify efforts with AFSC to stress quality of software in weapon and support systems. A more active and aggressive role in design reviews, contractor development progress monitoring, and testing is required. In addition, AFLC should specify acceptance test criteria prior to accepting PMRT.
- Initiate action to design, develop, and acquire a software repository for storing copies of all ECS software masters.

2.2.2 ECS Support Tools

In many cases, continued development of software is required after PMRT and the software tools originally used to develop weapon system and support system software are not delivered to AFLC. These tools are necessary and thus must be procured or developed by AFLC personnel. A large number of these tools are required, particularly in the EW and OFP categories. Currently, insufficient attention is being given to developing universal software tools which could aid in software support of any or all ECS categories; instead, tools are being developed for "near unique" applications.

All ALC's have configuration management problems to some degree. The problems span all ECS categories and generally are the result of lack of implementation rather than lack of procedural and regulatory guidance. Although lack of documentation intensifies the configuration management problems, configuration management problems exist even where baselines are adequately described. Several configuration management activities are underway at the ALC's, but none have been adopted as a standard for operation of all AFLC agencies.

Support systems have grown in complexity to the extent that operational verification can be a significant proceeding. Such capabilities as exercise scenarios, simulations, and emulations are required to both verify and to exercise support stations. These tools are particularly applicable to the EW and OFP categories and to a lesser degree, to the other categories.

RECOMMENDATIONS

- Adopt a command-wide configuration management system for use by the ALC's. The configuration management should encompass automatic features that enhance system operating ease and utility and that adequately control all necessary ECS data.
- Identify software development tools envisioned as being needed within the next 5 years and then structure an approach to acquiring the tools through off-the-shelf procurement, in-house development, or contractor development.
- When possible AFLC should design and develop or acquire standard scenario and simulator inputs to verify support systems. This approach should be extended to an entire set of IV&V capabilities.

2.2.3 ECS Support Policy and Guidance

Aircrew training devices and simulators are often developed with substantial architectual differences from their representative weapon systems and avionics. Consequently, a change to the weapon system does not necessarily correlate to a similar change in the ATD. In fact,

these changes are often independent to the extent that redesign of the ATD or simulator is necessary. This problem could be reduced by ensuring more commonality of equipment components and software between the weapon system and its trainer or simulator.

Support of ECS software is an engineering intensive activity. Current logistics procedures and regulations need to be reassessed in the context of efficient application to this rapidly increasing engineering role. Also, recent acquisition emphases on such areas as interoperability, standardization, and design for testability need to be solidified into guidelines for both AFSC and AFLC. The result of applying these emphases should lessen the overall support demands upon AFLC in future years.

As operational capabilities of weapon systems have become more integral with ECS software so has intelligence data become more integral. Software changes for EW and OFP systems are very dependent upon real-time intelligence data inputs. The potential for C-E and ATD use of real-time intelligence data is high. Reliance upon intelligence data indicates a more intimate interface with intelligence agencies is necessary if ECS support is to be provided.

RECOMMENDATIONS

- Coordinate with AFSC and adopt a policy which maximizes consistency between weapon system and ATD's and avionics and simulators.
- Establish a group to assess the applicability of existent regulations, procedures, and organization to the escalating engineering role in AFLC.
- Establish an AFLC group to determine the extent of interoperability, standardization, design for testing, etc., that is practical for AFSC/AFLC implementation.
- Begin budget and implementation planning to conceptualize the AFLC/Intelligence interface and an approach to acquisition of necessary AFLC capabilities.

2.3 ECS TECHNOLOGY FORECAST

TRW technologists forecast the effect of technological advances that will occur during the next ten years on AFLC's support of embedded computer systems. The ECS technology forecast, described in Volume VIII, is driven by two key trends.

1. Accelerated proliferation of microprocessors, avionics computers, and special-purpose processors within Air Force weapon systems and test equipment is envisioned during the next ten years. More subsystems will be equipped with internal circuit-board computers, thus displacing many stand alone embedded computer systems.

2. Demographers expect the college-age population to be 2.5 million students less in 1990 than during the 1970's peak. AFLC will need to train thousands of new programmers and computer technicians during the next ten years. An increase in productivity will become essential if AFLC is to maintain the readiness of Air Force equipment.

Nine technology advances have been identified that will strongly affect AFLC's support of ECS during the next ten years. In connection with each technology, specific actions are recommended. Also recommended are four management-oriented initiatives that will assist AFLC's economic adaptation to the technological advances.

2.3.1 Intercenter Networks[†]

It is feasible to interconnect all ALC's and Headquarter AFLC with a communication net, whose bandwidth could be 4 KHz (telephone lines) to 6 MHz (satellite lines). The network could be used for

- Closed Circuit Television (CCTV), as a training and conferencing aid;
- Distributed Integration Support Facility (ISF) simulations; and
- Operator-interactive data exchange (management information, software, inventory, and scientific computing).

[†] Detailed discussion in Section 2, Volume VIII.

This intercenter net would increase productivity of the technical staff, avoid duplicate development, and reduce training costs.

RECOMMENDATIONS

- Analyze intercenter needs (number of users, data rates, time delays, encryption, etc.) and costs associate with alternative implementations on a priority bases. An AFLC skill center should be charged with the analysis and subsequent implementation.

2.3.2 Distributed Integration Support Facilities[†]

Distributed-ECS avionics are being used in many new weapon systems. The embedded distributed computers serve such things as the radars, weapon delivery, engine control, air data, flight control, IFF-fusion, navigation, air data, digital radio, cockpit displays, electronic-warfare pods, and optic pods. Integration Support Facilities (ISF) use simulations of those subsystems and their environment for the following purposes:

- software maintenance,
- hardware integration, and
- hardware maintenance (for "check-out-ok" LRU's).

Distributed Integration Support Facilities (ISF's) are those in which subsystem simulations are located at several different ALC's. Distributed ISF's should share expensive host computers, peripherals, sensor stimulus generators, etc. among several weapon systems and should concentrate scarce specialists into skill centers. The network cost may offset the saving in duplicate facilities but scheduling may present management problems. A preliminary analysis by TRW suggests that 56 kbps one-way data rates and 10 msec intercenter time delays are required.

[†] Detailed discussion in Section 3, Volume VIII.

RECOMMENDATIONS

- A distributed ISF should be simulated by AFLC at a collocated ISF, such as Sacramento, to determine the required data rates, error rates, and maximum allowable time delay. A distributed ISF should be compared to a collocated ISF using those data rates and using estimates of usage times in support of anticipated USAF programs. The output would be comparative cost and manpower for the two ISF concepts. AFLC should delegate the analysis to one of its skill centers for implementation of an AFLC-wide ISF plan.

2.3.3 Computer Nets[†]

A computer net is the interconnected group of embedded computers that comprise a distributed avionics system. These embedded computers perform:

- software maintenance,
- hardware integration, and
- hardware maintenance (for "check-out-ok" LRU's).

Nets designed by AFSC permit each subsystem's computer program to be written by the vendor's technology experts and permit some degree of fault tolerance. Inter-computer connections almost universally use the MIL-STD 1553B data bus; computers will soon use the MIL-STD 1750A instruction set or chips that execute that instruction set.

RECOMMENDATIONS

- Plan for ISF's in support of distributed avionics. Distributed ISF's may be the most economic solution to software support and hardware integration for distributed avionics.

- Coordinate with AFSC

  - To include extensive built-in test (BIT) in avionics that can induce and verify faults in fault-tolerance ECS nets;

  - To provide for disabling any computer in the net to permit testing and even dispatch with a failed ECS;

[†] Detailed discussion in Section 4, Volume VIII.

- To avoid general multi-tasking nets although fallback-tasking (in which each computer executes a fixed set of tasks after failures in the net) is acceptable within AFLC's logistic system until 1990;
- To confine mission-related software changes to one computer in the net; and
- To put mission-independent changes in ROM to eliminate inadvertent erasures.

- AFLC should analyze automatic test equipment versus BIT requirements and make appropriate recommendations to AFSC.
- Analyze the economics of using MIL-STD 1750A chips in aircrew trainers. These chips offer the opportunity to load flight computer programs directly into the trainers with few changes, instead of requiring complete re-coding as at present.

2.3.4 LSI-VHSIC[†]

Fast, dense LSI chips are now available and are used as arithmetic/logic units, clocks, memory elements, and input-output devices in ECS. Special-purpose processor chips are being incorporated into military computers to perform correlations, convolutions, encryptions, fast-fourier transforms, MIL-STD 1553B bus interfacing, etc. Chips will shortly be available that execute the MIL-STD 1750A instruction set. Beginning in 1984, VHSIC Phase I chips will be commercially available. These chips will probably have densities of 20,000 gates/chip (as opposed to the current 1000 gates/chip) and clock speeds of 25 MHz (as opposed to the current 6 MHz clock speeds). These chips will be packaged as are today's chips and will be mounted on circuit boards.

The VHSIC program is specifically tailored toward military-unique chips that are not produced for the commercial electronics market. Thus, AFLC will begin to find them embedded in every variety of electronics equipment and in replacement devices. Most special-purpose

[†] Detailed discussion in Section 5, Volume VIII.

embedded computers will be incorporated directly into the devices they support, as one or more circuit boards. Standalone computers may be limited to central general-purpose processors in communication stations or surveillance aircraft. The VHSIC program will develop radar-oriented signal processor chips that will replace today's programmable general-purpose microcomputers. LSI and VHSIC microcomputers will also be used in optics pods, electronic-warfare pods, and communication radios. Special-purpose navigation communication chips are in development that will reduce the multiplicity of receivers and transmitters to a small number of boxes that will perform the same functions with higher reliability. Due to the extensive use of BIT in chips and in circuits, flightline ATE may nearly disappear, leaving an array of computer-driven special-test equipment in maintenance shops.

The adoption of a standard ECS circuit board (either an input-output standard or power, environment, and size standard) by AFSC would greatly simplify logistics and repair.

RECOMMENDATIONS

- Analyze the benefits, if any, of standardized internally embedded ECS boards.
- Assist in the development of microcomputer-based high order languages and compilers for the ECS chips to be found in retrofit equipment. Encourage AFSC to use these languages in new equipment. The languages should be dialects of Ada and J73.
- Develop software tools appropriate to each microcomputer or encourage AFSC to use the same tools across many programs.
- Procure special-purpose hardware to support LSI/VHSIC, such as logic analyzers, PROM programmers, ROM simulators, and hot benches for testing interfaces among distributed computers.
- Develop ISF's appropriate to each distributed avionics system.

2.3.5 High Order Languages[†]

A high order language (HOL) is an English-like language, with a vocabulary and syntax, whose compiler automatically writes machine instructions for a computer. DOD had 150 languages (not all HOL's) in use in 1978, many of which are used within AFLC. Various DOD directives of the late 1970's require that future software be written in one of three HOL's: JOVIAL J73, Ada, or ATLAS.

> JOVIAL J73: The J73 dialect of JOVIAL is the language in which MX, DAIS, LANTIRN, IUS, and other software are being written. J73 will probably be used in the upgrades of KC-135, F-111, E4, and the Satellite Control Facility. Insofar as the language is standardized across all programs, AFLC will use less manpower to maintain software after PMRT. AFLC support of J73 will begin in 1983.
>
> Ada: This language is being developed by DOD and is expected to become standardized in the NATO countries in 1982. Compilers are being developed but no program has yet adopted it. Ada should be adapted to microcomputers and might also be used for distributed multi-tasking nets in the future. AFLC support of Ada will probably begin in 1987.
>
> ATLAS: This language is a well-developed procedural language that produces machine code from English-language test sequences used in automatic test equipment. It is easy to read and use. In the future, ATLAS statements may be translated into Ada and JOVIAL, thus unifying all of AFLC's high order software. An interactive version of ATLAS may be desirable for testing. AFLC will support ATLAS throughcut the 1980 to 1990 period.

The amount of machine-language and assembly-language programming is expected to decrease as HOL's are more widely used. When used at all in AFLC, low-level languages will be used for modifying operating systems, writing input-output programs, and sensor interface routines.

[†] Detailed discussion in Section 6, Volume VIII.

RECOMMENDATIONS

- Consolidate high order language specialists into a central skill center or centers.
- Enforce AFSC usage of standard Ada, JOVIAL, and ATLAS on all new programs by identifying the cost of deviations at early DSARC reviews.
- Develop or encourage AFSC to develop problem-oriented dialects of Ada and J73 for simulation and testing.
- Develop J73 and Ada programming aids such as linkers, editors, emulators, auditors, etc.
- Participate in the Ada development process.

2.3.6 Emulation of ECS[†]

An emulation is a simulation of a weapon system computer (target computer) on a host computer. An emulation has many advantages such as the ability to develop software prior to delivery of a new or scarce target computer, to record intermediate results, and to debug software (provisions not usually contained in weapon-system computers). In aircrew trainers, an emulation of the weapon system computers would allow the flight software to be loaded with minor changes (for input-output) instead of having to be recoded for a large host. Emulations executing on scientific hosts typically run hundreds of times slower than real time; emulations executing on special-purpose emulations run 5 to 10 times slower than real time and require that "nanocode" instructions be written that emulate the microcode in the target computer. New parallel computers are being discussed in the literature that will execute nanocode in parallel CPU's, thus permitting real time emulation. The availability of MIL-STD 1750A chips will permit trainers to be constructed with the same chips as are used in weapon systems computers, thereby allowing the flight software to be used virtually unchanged.

[†] Detailed discussion in Section 7, Volume VIII.

RECOMMENDATIONS

- Concentrate emulation specialists in a skill center.
- Prepare an AFLC-wide emulation plan to avoid duplication of software and hardware in AFLC's. Relate emulations to ISF's.
- Encourage the AFSC aircrew trainer program office to develop general-purpose emulations for use in several trainers.
- Analyze the cost of retrofitting trainers with general-purpose emulators to reduce software rewriting.
- Develop an emulation language for writing microcode and nanocode.

2.3.7 Standardization[†]

AFLC is a principal beneficiary of standardization which can result in reduced parts inventory, reduced training, fewer software development facilities, less program-unique test equipment, less documentation, and higher programmer productivity. To enforce standardization, AFLC should identify the cost of deviating from standards to the DSARC during the earliest phases of programs, when changes are still economically possible. Standardization would reduce AFLC costs in the following areas while probably having little impact on weapon-system performance.

- Computer instruction sets.
- Data buses for interconnecting distributed computers.
- Standard software tools, especially for J73 and Ada. Examples of tools are emulators, compilers, linkers, and editors.
- High order languages.
- Automatic test equipment, especially general-purpose shop test equipment.
- Mathematical models of vehicles, weapons, environments, missions, and data reduction programs.
- Operator-interactive systems.

[†] Detailed discussion in Section 8, Volume VIII.

RECOMMENDATIONS

- Analyze historical data to prepare cost and reliability models of hardware and software maintenance. Estimate the cost of departure from standards.
- Identify departures from standardization for each pre-PMRT program and estimate the cost impact on AFLC at the DSARC I and II.
- Establish skill centers for high order languages, software tools, mathematical models, and operator-interactive software. These skill centers should prepare AFLC-wide plans, and should work with AFSC to enforce standards and develop AFLC internal standards where appropriate.

2.3.8 Built-In Test[†]

The use of built-in test (BIT) circuitry is increasing as chip costs fall. BIT detects failures and permits redundant elements to be simulated. BIT is designed to detect certain classes of failures. The trend in electronics design is toward the elimination of flight-line testers in favor of BIT and LRU-swapping. The trend in shop equipment is toward general-purpose computer-driven testers with adapters for LRU's. LRU's that "check-out-ok" or whose failure cannot be duplicated can be tested in a dynamic ISF, whose primary purpose is software development.

RECOMMENDATIONS

- The following approach is recommended to determine costs sensitivity to the design of BIT.
  - Analyze the mix of BIT and automatic test equipment to determine if an optimum mix exists. Determine the need for a small number of standard LRU adapters.
  - Determine the economical level of BIT in each type of LRU, including AFSC and AFLC costs and USAF mission costs (e.g., destroyed aircraft and a larger fleet to complete planned missions).
  - Ensure that fault-tolerant ECS include the means to induce faults and verify proper operation of BIT.

[†] Detailed discussion in Section 9, Volume VIII.

2.3.9 Operator-Computer Interaction[†]

The hundreds of computer terminals within AFLC have a variety of functions including

- Test processing,
- Inventory control,
- Computing,
- Integration Support Facilities,
- Trainers,
- Test sets,
- Management information systems, and
- Computer programming.

These terminals are made by many different manufacturers and contain varying degrees of intelligence, different operator-input devices, and different driver software. The method of changing the computer program to change formats and the interactive procedure by which the user calls formats differ radically. There is no standardization of software although several low-level standards are in development. Equipment and software exhibit rapid obsolescence and are not, in general, interchangeable among manufacturers. Software packages are sold by many manufacturers for word processing, tabular displays, and pictorial displays.

RECOMMENDATIONS

- In this fluid marketplace, standardization is not currently recommended. Instead, the follow approach warrants consideration.
  - AFLC should undertake a survey of operator-interactive needs: How many users are there and what do they do? How many must use, (and therefore learn) systems of more than one manufacturer? How many terminals of each type are in inventory?

[†] Detailed discussion in Section 10, Volume VIII.

- AFLC should establish a skill center of interactive-software specialists who can write drivers and applications-independent graphics. They would be in demand to augment purchased software packages and to interface terminals and computers that are otherwise incompatible. They would also have a test bed for development of interactive software.

- Adapt standards as they are created. A low-level ANSI core graphics standard now exists and the ACM-Siggraph standard is being prepared. AFLC may wish to participate in the development of newer standards if the survey shows that its needs are unique.

2.3.10 Management-Oriented Initiatives

Management-oriented initiatives can significantly dilute the economic impact of technological advances and thus greatly assist in AFLC's economic adaptation to these advances.

RECOMMENDATIONS

- **AFLC should increase the productivity of its technical staff by adopting software and hardware standards and by installing an intercenter network.**

- **AFLC should identify AFSC-proposed deviations from standards starting at DSARC-1 and should identify the projected costs to AFLC of those deviations. AFLC should spend 2 to 5 percent of support costs analyzing designs and should propose preferred designs to AFSC and DSARC.**

- **In order to make better use of increasingly scarce specialists, AFLC should establish centralized skill centers for ISF simulations in support of distributed avionics networks, high order languages, software tools, mathematical models, operator-interactive software, management of the intercenter network, and the standardization effort. AFLC should invest 2 percent of support costs planning these systems and facilities on an AFLC-wide basis.**

- **AFLC should analyze and publish historical data on the cost of maintaining and supporting ECS hardware and software and on failure rates.**

2.4 NATIONAL SOFTWARE WORKS INVESTIGATION

A separate study task† was an investigation and assessment of the current and future applicability of the National Software Works (NSW) to AFLC software support requirements for ECS. Primarily, these results were obtained by contrasting current NSW status and available tools with current AFLC ECS software support requirements. The assessment of future applicability was based upon a comparison of NSW status and tools with a series of capabilities postulated to meet future AFLC requirements. Finally, the assessment encompassed a consideration of networking as it would generally apply to future AFLC needs.

RECOMMENDATIONS

- AFLC should not depend upon the NSW as a near-term capability. AFLC should depend upon NSW as a future capability only if the NSW is significantly upgraded.
- Networking is definitely applicable to AFLC ECS support requirements and acquisition planning for an applicable network should be initiated.

† Documented in Volume IX.

3. LONG RANGE PLAN (OUTLINE)

The long range plan will describe the recommended additional administrative and programmatic initiatives to be taken by HQ AFLC to achieve a mission effective Embedded Computer System (ECS) support posture by 1990. This outline discusses the structure and content and the approach to development of the long range plan.

3.1 BACKGROUND

Embedded computer systems are defined as computer systems that are an integral part of a larger electronic or electromechanical system. The specific categories of ECS included in the plan are

- Aircrew Training Devices (ATD),
- Automatic Test Equipment (ATE),
- Communications-Electronics (C-E),
- Electronic Warfare (EW), and
- Operational Flight Programs (OFP).

Support concepts for the five categories of ECS have evolved over a period of time. This is also true for the definition of the ECS categories themselves. Beginning with Project Pacer Flash, three categories were defined (OFP, ATE, and ATD) with two others (EW and C-E) added later. Although the categories and concepts have been evolving for some time, documentation of the categories and support concepts, at least in part, occurred very recently. Current documents establish: (1) an Avionics Integration Support Facility (AISF)/Integration Support Facility (ISF) concept for ECS categories OFP, EW, and C-E (2) a Software Support Center (SSC) concept for ECS category ATE, and (3) the Development Engineering Prototype Site (DEPS) concept for ECS category ATD.

A clearer definition of support requirements for the various ECS categories has also emerged along with the firming up of the category and concept definitions. The common support requirements that apply across all five ECS categories are described in the requirements baseline volumes as a generic ECS change process. This set of generic

requirements, when combined with category peculiar requirements such as rapid reprogramming for EW, or nuclear weapons in the case of OFP, comprise the ECS support requirements for a given ECS category. The change process in abbreviated form, which is common to all ECS categories in the post-PMRT time period is described in Table 3-1.

In the past, support objectives for the various ECS categories have been stated at a high level with implementation mostly on a case by case basis even within individual categories. This was done, at least in part, to validate several support approaches but has resulted in the current support posture with various approaches to ECS support and has spawned a number of support problems which are discussed in the Phase II report. An approach to the resolution of these problems, many of which are long standing, is dependent upon clearly stated support objectives and implementation of specific initiatives.

3.1.1 Source Material for the Long Range Plan

The Phase II report describes the current support posture and provides assessments of the deficiencies/problems encountered in the support of the five categories of embedded computer systems. In addition, it contains a forecast of the impact of future technology with regard to ECS support and assesses the applicability of the National Software Works (NSW) to near-term ECS support requirements. Based on the information documented in the Phase II report and additional data generated in Phase III, the long range plan will describe a recommended course of action to attain the future ECS support posture.

3.1.2 Long Range Plan Development Tasks

The initial task in developing the long range plan during Phase III is to postulate/project a future ECS support environment. This activity is shown as Step 1 in Figure 3-1. This task, which requires close coordination with AFLC/LO, involves the synthesis of stated or documented, as well as perceived, ECS support needs into an objective or target ECS future support posture. The remaining task shown as Step 2 in the figure, is to determine any additional initiatives to achieve the future support posture and to categorize them along with the ECS support initiatives described in the Phase II reports into administrative

Table 3-1. Generic ECS Support Requirements

ECS Change

- Receive and process request
- Preliminary analysis and problem/deficiency definition
- Preliminary resource allocation and scheduling

Change Analysis and Specification

- Feasibility
- Requirements decomposition/definition
- Preliminary design
- Detailed design
- Generate change proposal

Engineering Development and Unit Test

- Develop the change
- Perform engineering tests

System Integration and Test

- Test ECS system performance
- Test weapon system performance
- Produce test reports

Change Documentation

- Document ECS change
- Update ECS baseline
- Configuration control

Certification and Distribution

- Certify documentation
- Distribute revised ECS data
- Provide installation procedures/instructions

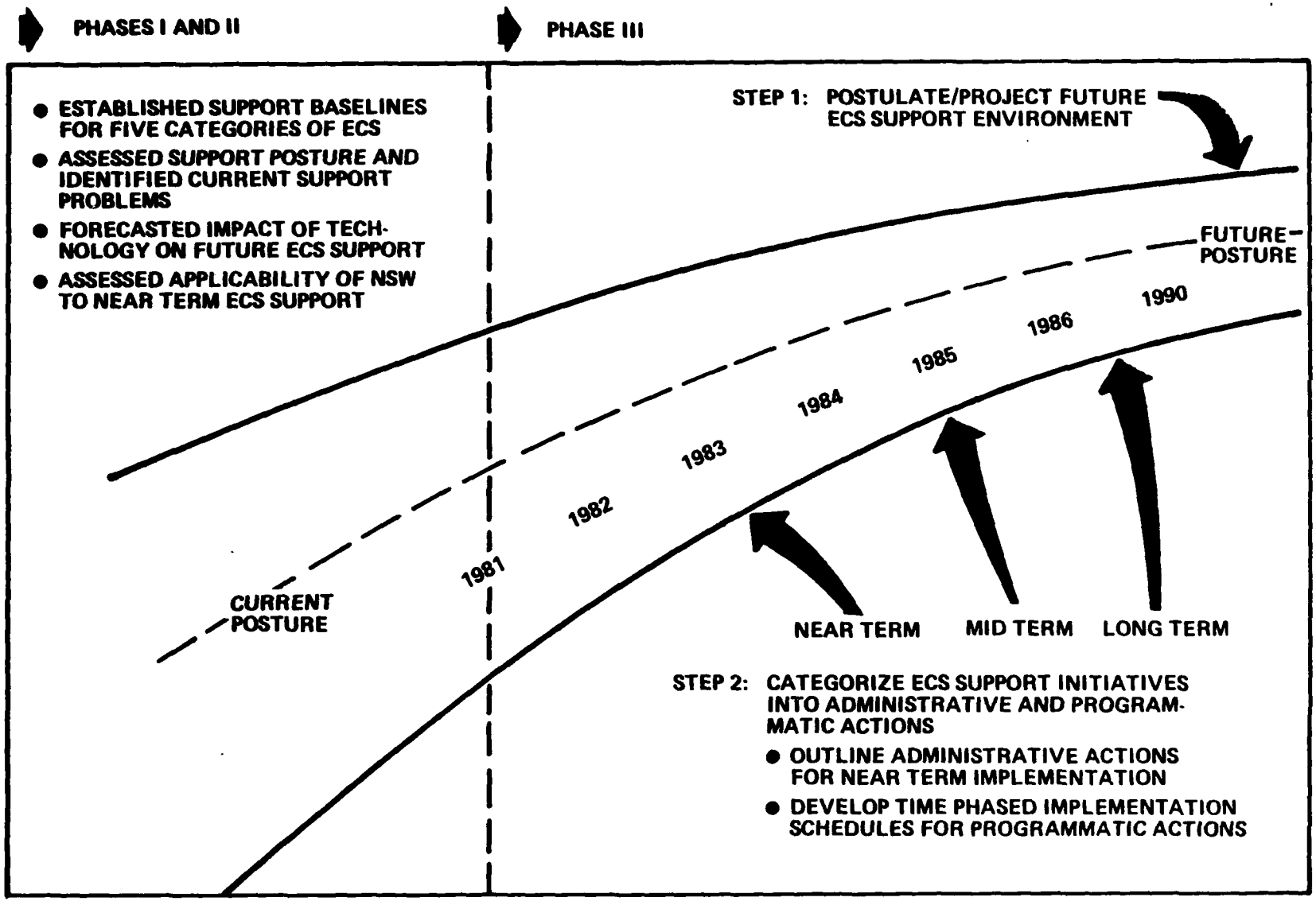


Figure 3-1. Road to ECS Support in the 1980's

and programmatic actions. The long range plan will contain an outline of the administrative actions which are within the government domain and recommended for near-term implementation. The plan will also contain the time phased implementation schedules for the recommended programmatic actions. This latter activity is currently envisioned as a major portion of the study effort during Phase III.

3.1.3 Scope of the Long Range Plan

The long range plan focuses on weapon and support systems containing embedded computer systems and emphasizes the computer program (software) aspects of ECS support. The plan addresses the management and technical activities necessary by HQ AFLC for attainment of a mission responsive support posture for each of the five categories of ECS during the 1980's.

The long range plan will conform with the current AFLC management concept of centralized control and decentralized implementation of the activities required for support of the various categories of ECS. Major emphasis in the plan is on the support requirements, concepts, organization and resources (people and tools) necessary to achieve a recommended future support posture for a rapidly increasing ECS support role. The plan focuses on the ECS support requirements that are applicable or common to all five ECS categories, thereby increasing the command-wide benefits of implementation of any given recommended activity. Conceptually the plan will consider extensive use of both internal and external networking to the ECS support facility locations. In addition, a major theme in the plan is standarization of tools, equipment, and procedures.

3.2 LONG RANGE PLAN DEVELOPMENT APPROACH

The first major task in developing the long range plan is to postulate/project a future ECS support environment that satisfies: (1) the projected requirements contained in the current Statement of Need/Mission Element Need Analysis (SON/MENA), (2) other requirements not specified in the SON/MENA that are discussed in the Phase II recommendations/alternatives and in the technology forecast, (3) the common and unique ECS

category support requirements documented in the baseline reports, and (4) the current and projected ECS category support concepts. This postulated/projected ECS support environment will be coordinated with HQ AFLC/LO and stated in the form of objectives/goals. The other major task to be accomplished during Phase III is to determine the actions necessary to achieve these objectives/goals. These actions consist primarily of: (1) initiatives to correct deficiencies in the current support posture and (2) new initiatives to satisfy the future objectives/goals and achieve the future support posture. The overall process is shown in Figure 3-2.

The currently envisioned method for presenting the implementing steps to attain the future ECS support posture is to group, when possible, the actions/initiatives into either administrative or programmatic actions. The methodology also groups and addresses the selected initiatives in three basic time periods. The time periods under consideration are the near-term (1-2 years), mid-term (1-5 years) and long-term (1-10 years). The remaining task is to outline the administrative actions necessary for near-term implementation to correct deficiencies and develop the time-phased implementation schedules for the programmatic actions.

An example of an activity which lends itself to administrative/directive solution and is a candidate for near-term implementation is presented in summary form in Table 3-2. This particular activity is a sensitive and volatile ECS support issue of long standing that is clearly within the government policy and guidance domain. Consequently it would be presented in outline form in the long range plan.

An example of an initiative that involves adminstrative action to implement but is primarily programmatic in nature, a candidate for near term implementation, and is considered appropriate for more definitive implementation detail is configuration management. Table 3-3 briefly summarizes this candidate initiative.

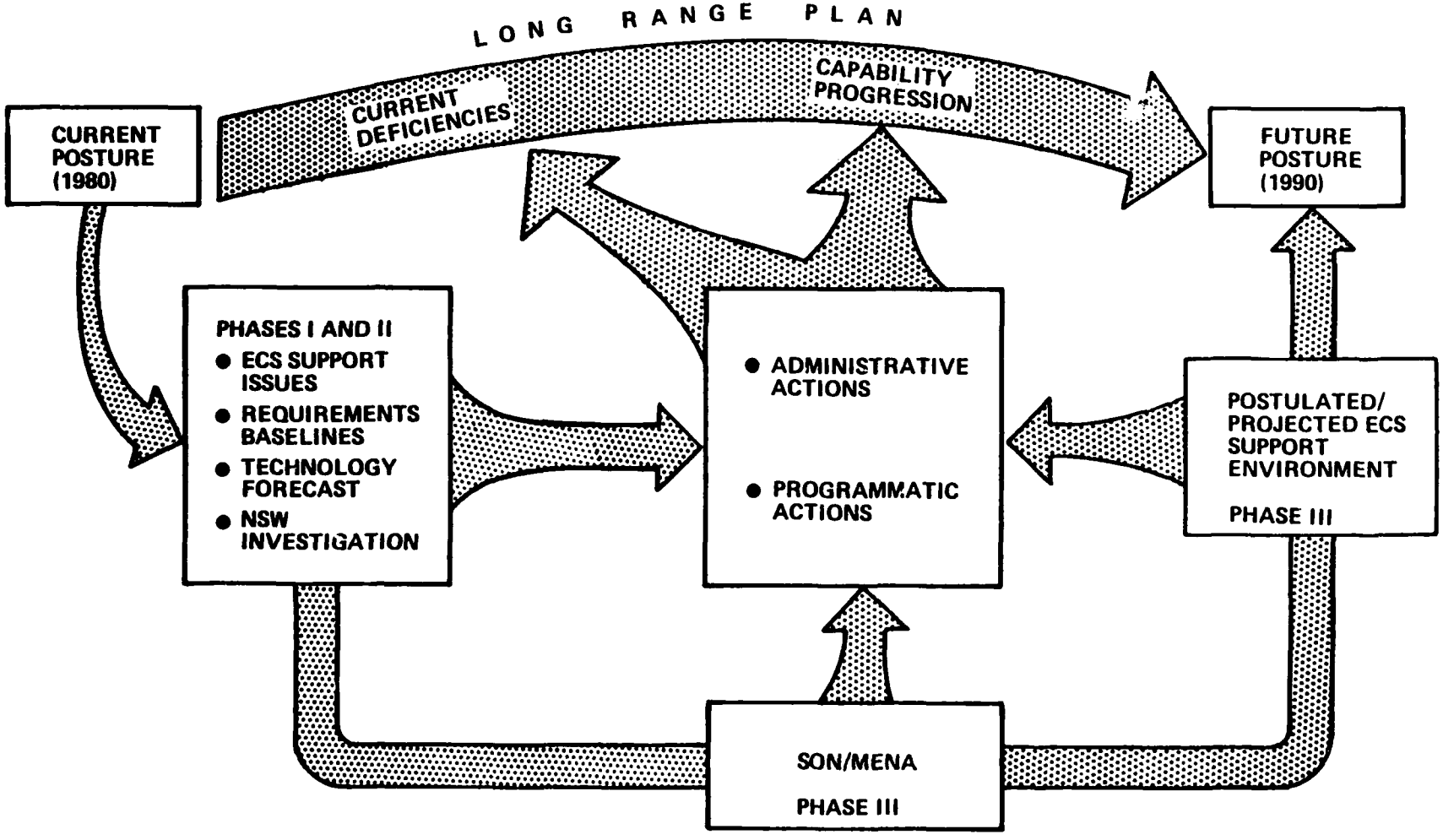


Figure 3-2. Long Range Plan Development Approach

Table 3-2. Example Action/Initiative

- Item: Funding
- Objective: Establish/clarify policy and guidance for support of Embedded Computer Resources.
- Recommendation:

  Establish definitive funding lines within AFR 800-14 and program management directives to route pre-PMRT funds to AFLC agencies to enable adequate participation in the acquisition process, acquire appropriate O&S support facilities, and perform/participate in IV&V activities.

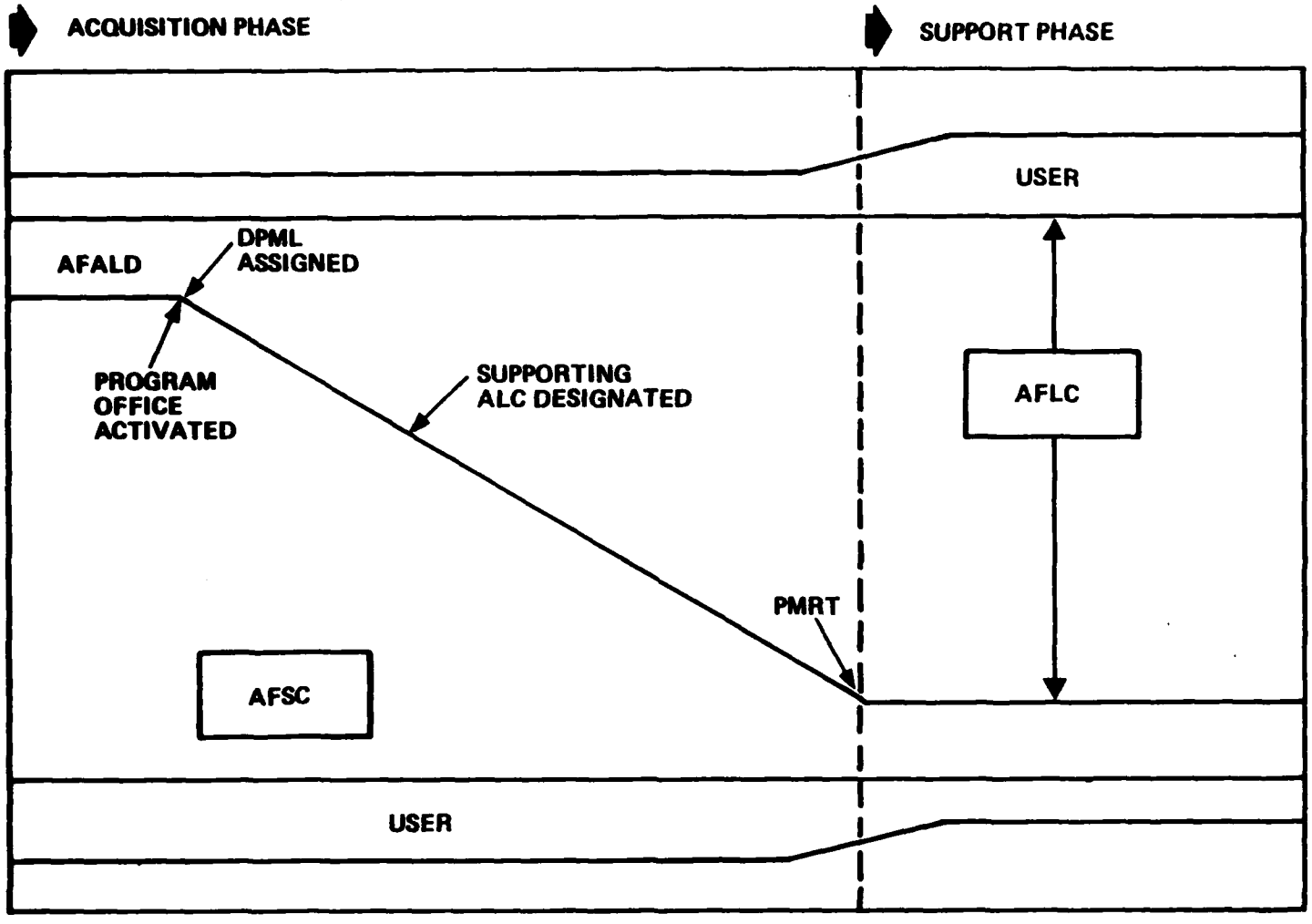
Table 3-3. Example Action/Initiative

- Item: Configuration management
- Objective: Establish command-wide configuration management system for ECS support.
- Recommendations:
  1. Develop/define ALC requirements for automated configuration management.
  2. Develop/acquire standard tools which satisfy these requirements for each ALC.
- Methodology: Establish project/program - organic/contractor to define requirements and select/develop tools.

3.3 ECS SUPPORT ORGANIZATION AND RESOURCES

The organizational responsibilities and interfaces associated with the programmatic initiatives to be contained in the long range plan will be presented in a life cycle context and within the framework shown in Figure 3-3. The currently envisioned focus for the top level responsibilities and external interfaces is as follows: HQ AFLC has responsibility for ECS support policy and guidance and primarily interfaces with other MAJCOMS. The Acquisition Logistics Division has responsibility for ECS support system acquisition and primarily interfaces with the Air Force System Command's Product Divisions. The Air Logistics Centers and the Aerospace Guidance and Meteorology Center have responsibility for ECS support system operation and primarily interface with the weapon system users.

The long range plan also identifies the resources such as personnel, equipment and facilities that are related to the recommended programmatic actions. In addition is discusses: (1) the scope of the management and technical skills and training programs necessary to acquire the human resources for effective ECS support during the 1980's and (2) the required equipment (tools) and facilities (brick and mortar) in terms of the federal budget cycle and military construction programs.



NOTE: USER MAY ALSO DO PART OR ALL OF ECS SUPPORT

Figure 3-3. ECS Acquisition and Support Interfaces